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NATIONAL AIR INTELLIGENCE CENTER

PERFORMANCE ANALYSIS OF MILITARY SPACE IMAGING SYSTEMS

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Military space imagery reconnaissance is the use of reconnaissance remote sensors loaded aboard space craft in order to acquire military targets, military installations, as well as intelligence information such as great military operations for the purposes of activities. Due to the special nature of missions, they pose special requirements for the performance and technological indices of imagery reconnaissance remote sensing systems--for instance, they require reconnaissance speeds to be fast, broad ranges of coverage, reliably mature technology, high space resolutions, and the images acquired to be directly perceived, clear, real, easy to process and interpret, and so on. This article carries out an introduction of the key performance characteristics possessed by space imagery reconnaissance remote sensing systems.

SPACE RESOLUTION

Speaking in terms of military reconnaissance, the space resolutions of remote sensing images are indicative of the capability of imagery to resolve minimum dimensions of ground targets. Due to military imagery reconnaissance being primarily acquired using spacial geometry forms as the key characteristics of the images of military targets, military installations, as well as weapons, and so on, resolutions, therefore, then become one of the most important and most basic technological indices associated

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* Numbers in margins indicate foreign pagination. Commas in numbers indicate decimals.

with military imagery reconnaissance systems. The higher system resolutions are, the greater amounts of information obtained then are, and the more plentiful the intelligence information extracted from them then is. Speaking in terms of a definite meaning, the resolutions of remote sensing images are manifested in a concentration of reconnaissance performance characteristics of military imagery reconnaissance systems.

As far as reconnaissance satellites executing different reconnaissance missions are concerned, the imagery remote sensors possess different resolution requirements. Generally speaking, the resolutions required by reconnaissance satellites executing ordinary missions can be somewhat low. However, the resolutions of reconnaissance satellites carrying out detailed missions, by contrast, must be somewhat high.

The United Nations weapons inspection team, in an investigative report, believes that carrying out ordinary missions requires resolutions of 3-5 meters. Executing detailed missions, by contrast, requires 0.5-2 meter resolutions. Moreover, the resolutions required by detailed analysis and description of military targets ought, by contrast, to be within 0.15-0.3 meters. In the appended table are listed resolutions required for reconnaissance and interpretation of different military targets.

On the basis of many years of experience and practical implementation, generally speaking, 3-10 meter resolutions are capable of satisfying the requirements of ordinary missions. However, as far as detailed reconnaissance of military targets is concerned, the resolutions, by contrast, must be higher than 1 meter.

Resolutions Required by Different Reconnaissance and Interpretation Missions (Meters)

目 1 标	发 2 现	大致识别 3	确切识别 4	描 5 述	技术分析 6
7 桥梁	6.00	4.60	1.50	0.90	0.30
8 通信(雷达)	3.00	0.90	0.30	0.15	0.04
9 无线电	3.00	1.50	0.30	0.15	0.15
10 补给品仓库	1.50	0.60	0.30	0.03	0.03
11 部队(营地,道路)	6.00	2.00	1.20	0.30	0.08
12 机场设施	6.00	4.60	3.00	0.30	0.15
13 火箭与火炮	0.90	0.60	0.15	0.05	0.01
14 飞机	4.60	1.50	0.90	0.15	0.03
15 指挥控制司令部	3.00	1.50	0.90	0.15	0.03
16 地地/地空导弹基地	3.00	1.50	0.60	0.30	0.08
17 水面舰船	7.60	4.60	0.60	0.30	0.08
18 核武器(设施)	2.40	1.50	0.30	0.03	0.01
19 坦克、车辆	1.50	0.60	0.30	0.05	0.03
20 地雷区	9.00	6.00	0.90	0.03	—
21 港口(码头)	30.50	15.00	6.00	3.00	0.30
22 海岸、登陆滩头	30.50	4.60	3.00	1.50	0.08
23 铁路编组站	30.50	15.00	6.00	1.50	0.60
24 公路	9.00	6.00	1.80	0.60	0.15
25 城市(区)	61.00	30.50	3.00	3.00	0.30
26 地形、地貌	—	91.00	4.60	1.50	0.15
27 浮出水面的潜艇	30.50	6.00	1.50	0.90	0.03

Key: (1) Target (2) Discovery (3) Rough Identification (4) Firm Identification (5) Description (6) Technical Analysis (7) Bridges (8) Communications (Radar) (9) Radio (10) Replacement Parts Storage (11) Units (Bivouacs, Routes) (12) Airfield Installations (13) Rockets and Artillery (14) Aircraft (15) Command and Control Headquarters (16) Ground to Ground/Ground to Air Missile Bases (17) Surface Vessels (18) Nuclear Weapons (Installations) (19) Tanks, Vehicles (20) Mine Field (21) Harbor (Piers) (22) Coast, Landing Beaches (23) Railway Marshaling Stations (24) Highways (25) City (Zones) (26) Terrain, Land Forms (27) Submarines Floating in the Surface

With regard to scanning imagery systems, use is generally made of instantaneous field of view (IFOV). This concept is to measure and represent the reconnaissance performance and resolution capabilities. People sometimes take spacial resolution and instantaneous field of view and mix them up in discussions. In reality, they are two completely different concepts. As far as instantaneous field of view is concerned, some also call it image element resolution. This refers to the dimensions of the scope of the ground surface covered by the instantaneous ground description associated with one detection device image element.

With regard to the relationship between space resolution and instantaneous field of view, theoretically speaking, space resolution is equal to 2 times the square root of 2 fold the field of view. In actual realization, when the contrast ratio is 2:1, the space resolution is equal to 2-2.4 times the instantaneous field of view. When the contrast ratio is 100:1, space resolution is equal to 1.4-1.6 times the instantaneous field of view. In situations of standard contrast (2.5:1), space resolutions are approximately equal to 2 times the instantaneous field of view.

RATE OF OVERLAP

The rate of image superposition refers to the ratio between the dimensions of the part of two adjacent images double covering a ground area in the two images and the dimensions of a whole image in the same direction during sensor imaging processes. Normally, it is represented as a

percentage. It is one of the key technological indices associated with imagery remote sensing.

It is only when remote sensing devices possess adequate rates of overlap that it is possible to obtain three dimensional imagery. As far as three dimensional imagery is concerned, with regard to the interpretation of specially designated military targets as well as the drawing of military terrain maps, it is indispensable.

In the case of cubic space reconnaissance imagery, it is obtained from the crosswise overlap between the lengthwise superposition along the orbital flight of space craft and that perpendicular to the direction of orbital space craft flight. Generally speaking, space flight sensor imagery possessing 60% overlap rates is capable of satisfying the requirements associated with the three dimensional interpretation of military targets and the drawing of military terrain maps. Satellite mapping outside China is generally all completed by imagery reconnaissance satellites. In this way, not only satellite reconnaissance requirements are satisfied, but also the imagery material required for satellite mapping is taken care of.

ORBITAL COVERAGE PERIODS AND REVISITING CAPABILITIES

In spacial terms, space reconnaissance possesses the capability to reconnoiter the entire globe. In terms of reconnaissance times, it possesses the capability for repeated reconnaissance of important areas and targets in all weather and within short periods. It is one of the most outstanding special characteristics of space flight reconnaissance. It is also a most basic requirement for space flight imagery sensor devices.

In order to realize coverage of the entire globe, reconnaissance satellites must opt for the use of polar orbits or quasi polar orbits. In order to carry out correlation and mosaic inlay on the same area, the angle of altitude of the sun when images are taken are best if they are the same or basically the same. Therefore, the optimal orbits for imagery reconnaissance satellites are solar synchronous orbits or quasi solar synchronous orbits.

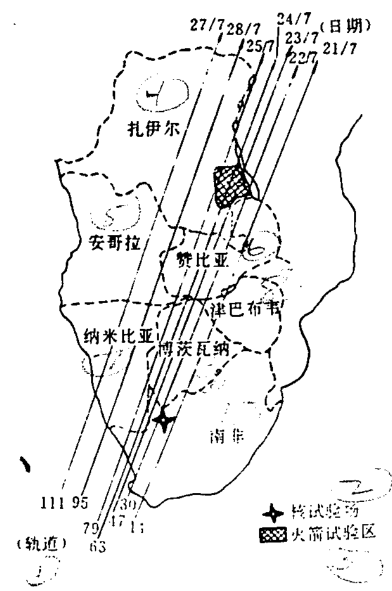
Satellite orbital coverage periods refer to the time periods required for imagery reconnaissance satellites to cover the entire globe. As far as satellite revisiting capabilities are concerned, they are also called satellite repetition reconnaissance periods and refer to the time period intervals required for reconnaissance satellites to reconnoiter the same area two consecutive times. These are all important technological indices for reconnaissance satellites. In order to obtain in a timely manner intelligence on a certain key area or key target, as well as to carry out repeated reconnaissance of a certain area within the shortest time possible--so as to grasp its dynamic and changing status--it is necessary for reconnaissance satellites to possess the shortest orbital coverage periods and revisiting capabilities.

In order to realize the objectives above, imagery systems then need relatively large field of view angles and adequate angles of inclination for observation capabilities. Using France's Sibote (phonetic) global natural resource satellite as an example, due to photoelectric imagery scanning systems being equipped with a planar reflection mirror (maximum reflection mirror deflection angle is ±27°) which is capable of being controled from the ground to change observation angles, it is therefore the case that satellites not only possess, in the same orbit, capabilities

to observe the two sides of the track, but also, in the same orbit, a capability to observe the same area, thereby making the satellite possess an independent, rapid revisiting and three dimensional observation capability. Although the Sibote satellite's orbital coverage period is 26 days, its shortest revisiting capability is, however, only 1 day. The longest is still only 4 days. The average is 2.3 days.

TIMELINESS OF INFORMATION OBTAINED

As far as timeliness and accuracy are concerned, they are the two basic elements of intelligence. Speaking in terms of military intelligence, this is particularly the case. This is especially true under conditions where high technology is used in all areas of war. The real time character and speed of space reconnaissance means then demonstrate even more clearly their special position and role. For instance, during the Gulf War, the U.S. made large scale use of its military space technology systems in the war. This is only one very good example.



Reconnaissance Maneuver Schematic for the Former Soviet Union's Cosmos 932 Satellite

Key: (1) Orbit (2) Nuclear Test Site (3) Rocket Test Area (4) Zaire (5) Angola (6) Zambia (7) Namibia (8) Zimbabwe (9) Botswana (10) South Africa

Following along with the development of semiconductor technology, data recording, and data transmission technology--in order to improve the timeliness of intelligence--since the middle 1970's and the early 1980's, the U.S. and the former Soviet Union developed and launched, one after the other, fifth generation photoreconnaissance satellites, that is, digital transmission models of imagery reconnaissance satellites. Once they came out, the timeliness of the intelligence was then high. Satellite operating life was long. The digitizing of imagery and suitability for computer processing as well as military benefits were high. Moreover, they received serious attention and were in the good graces of intelligence circles and military policy making agencies. Although imagery resolutions during the initial period of this type of satellite were far from being as high as returnable type satellites, the advantages discussed above, however, were completely capable of making up for certain inadequacies in resolution. If assistance is also gotten from the coordinated utilization of communications satellites and data relay satellites, it is then possible to realize real time or quasi real time reconnaissance.

One authoritative source at the U.S. Central Intelligence Agency said, when talking about KH-11 satellites, "You can call them. When a satellite arrives at a target area in accordance with requests, you can then obtain a photograph. In conjunction with this, you can send it down. After that, within a short time, it is then possible to complete the processing and interpretation, in conjunction, printing it out, and send it into the hands of top policy makers in the White House and the Pentagon."

The author believes that digital transmission models of imagery reconnaissance satellites foreshadow and represent the direction of developments in the current stage of military imagery reconnaissance satellites.

MANEUVER RECONNAISSANCE AND EMERGENCY QUICK INSPECTION CAPABILITIES

Maneuvering reconnaissance, also called maneuvering orbital change reconnaissance or orbital maneuver reconnaissance, refers to methods opting for the use of alterations in reconnaissance satellite orbits so as to carry out reconnaissance to obtain the status and changes associated with a certain area or target within a specially designated time limit. It is a basic function which should be possessed by military imagery reconnaissance satellites. What is called emergency "quick look" refers to the carrying out of reconnaissance on areas and targets which need coverage on the basis of requirements within the shortest time period possible.

Imagery reconnaissance satellite maneuver reconnaissance and emergency fast inspection capabilities depend primarily on changes in satellite orbit and systems maintaining orbit for realization. It is also possible to obtain it through alterations in imagery system optical reflector mirror angles. The French Sibote (phonetic) satellite is just such an instance.

In the 1970's, in order to realize timely reconnaissance against certain nations, areas, and targets, the former Soviet Union also launched a type of what are called Quick Look Satellite photographic reconnaissance satellites. In actuality, this type of satellite is only the third or fourth generation of photographic reconnaissance satellites. It is nothing more than opting for the use of different operating orbits aimed against different reconnaissance objects. That is all. Once

reconnaissance missions are completed, they are immediately recovered. What is shown in a Fig. appended to this article is the status of the former Soviet Union's Cosmos 932 photographic reconnaissance satellite maneuver reconnaissance and emergency fast inspection.

CONCLUDING REMARKS

Besides the requirements discussed above, there are also special requirements for such things as imagery reconnaissance satellite scale clarities, the numbers of recoverable type photographic reconnaissance satellite rolls of film as well as the numbers of instances of recovery, the time intervals between recoveries, as well as satellite orbital operating life, and so on.

It goes without saying, the ultimate purpose of space reconnaissance and its maximum benefit is to obtain space reconnaissance intelligence in great amounts and high quality. It is necessary, as a guiding thought, to really plant the concept of taking intelligence as central, and, in conjunction with this, thoroughly implement it in all processes associated with reconnaissance space craft development, production, launching, and utilization. In particular, in situations where space craft, delivery devices, and remote sensing device technology have already passed the test, and satellites have been listed as military equipment, and, in conjunction with that, have already been introduced into use, this should be even more the case. As was discussed before, imagery resolution is the most important and most key technological index associated with imagery reconnaissance systems. It is also a concentrated manifestation of system reconnaissance performance and

benefits. It is necessary to use improving imagery remote sensing system resolution as the key point, developing and improving across the board space imagery reconnaissance system reconnaissance capabilities.

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